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Fig : 5 -

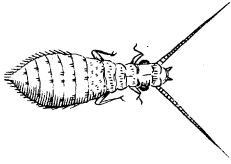
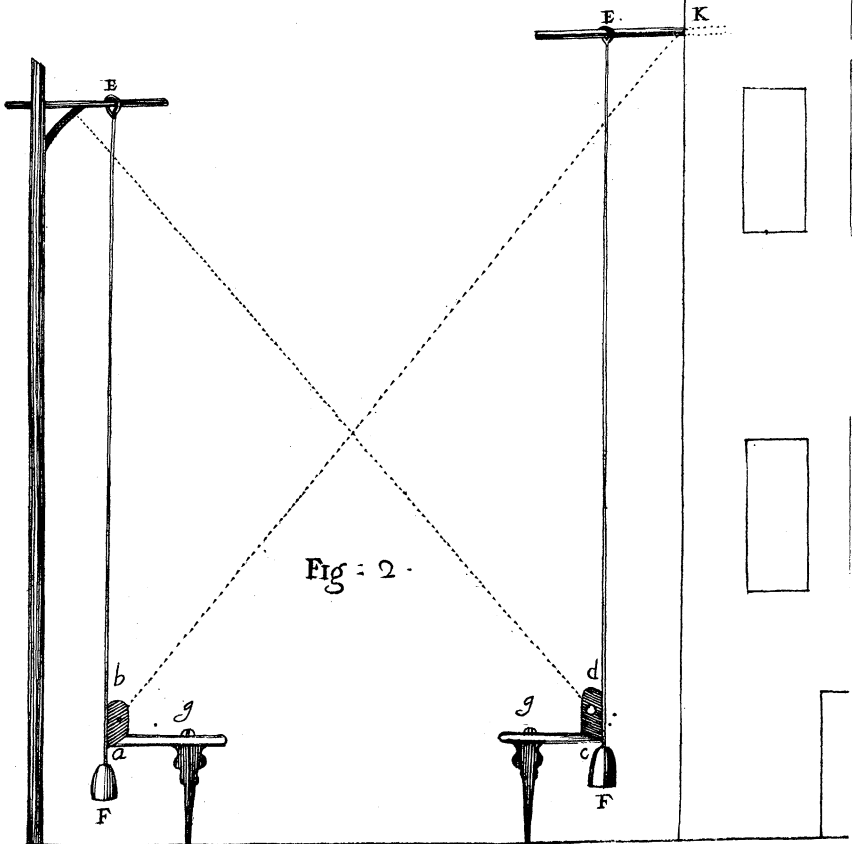
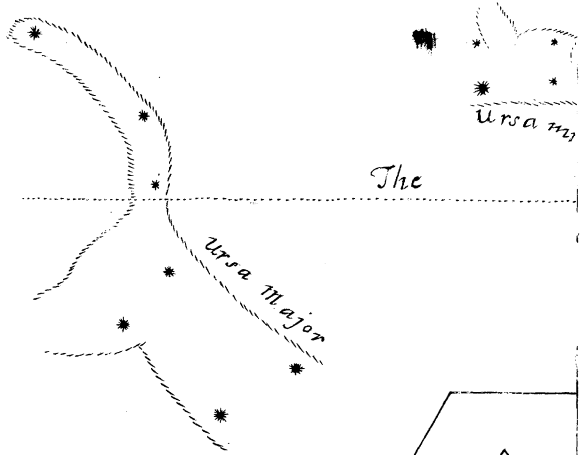
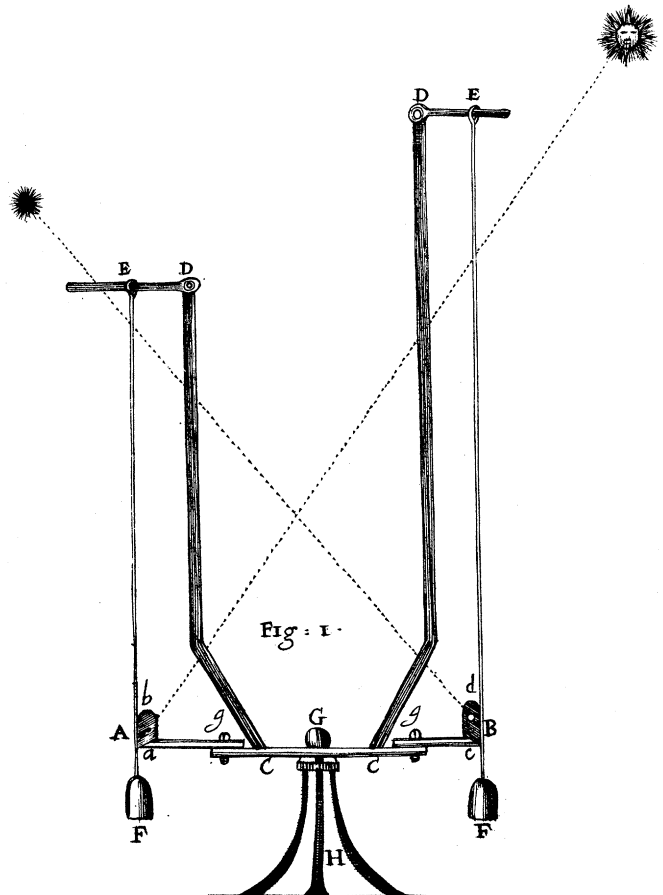
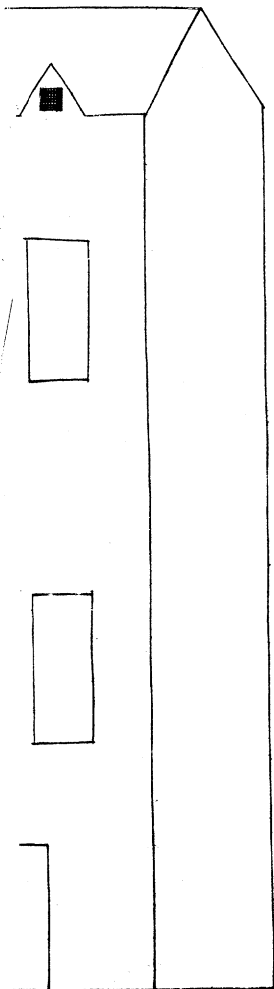
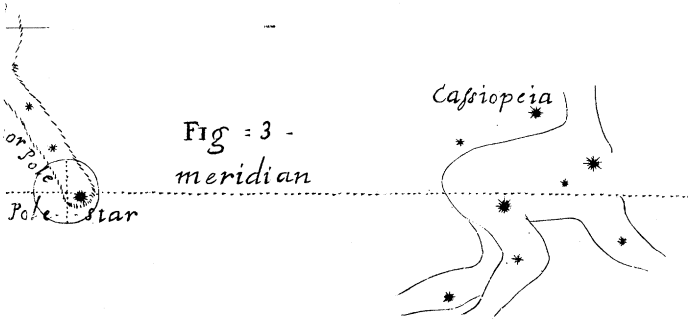


Fig : 4 -





18. Pectunculus fossilis crassius rostro acuto Striis majoribus.
 19. Pectunculus fossilis fascijs transversis undantibus notatis.
 20. Pectunculus vulgaris fossilis.
 21. Pectunculus fossilis Strijs majoribus & elatioribus.
 22. Pectunculus maximus fossilis Listerianum maximum referens.
 23. Pectunculites maximus Strijs latis.
 24. Concha parva fossilis fascijs transversis insignis.
 25. Concha longa fossilis fasciata.
 26. Conchites lævis maxima.
 27. Conchites parva fasciata.
 28. Trigonella minor sive vulgatio Anglica *Lithoph.* Brit. 816.
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III. An Instrument, for seeing the Sun, Moon, or Stars, pass the Meridian of any Place. *Useful for setting Watches in all parts of the World with the greatest exactness, to correct Sun-Dyals; to assist in the discovery of the Longitudes of Places, &c. By the Reverend Mr William Derham, F. R. S.*

AMong all the ways contrived for finding the Meridian of any Place, the most commodious I could ever meet with, or think of for common Use, is an Instrument of Sir *Christopher Wren's*, or two of Mr *Gray's*, or one published in the Appendix of a little Book, called *The Artificial Clockmaker*.

Sir *Ch. Wren's* contrivance I am informed is thus, At one end of a Ruler, erect a Sight, to see the Pole-Star, &c. through. At the other end set up two Circles of small Wire, one within the other; the Diameter of the innermost, equal to the doubled Tangent of the distance of the Pole-star from the Pole, the distance of the Sight being Radius; and the Diameter of the outermost Circle, equal to the double Tangent of the distance of the next Star to the Pole-Star, from the Pole. Your Instrument thus prepared, if you look thro the Sight, and bring the two Circles to the two Stars, whose distances from the Pole they represent; a Line passing through a Sight and Center of the Circles, is the Elevation of the Pole: and two Plumb-lines hung up, one over the Sight, the other over the Center of the 2. Circles, will exactly lye in the Meridian of the Place.

Mr *Gray's* Ingenious Contrivances being in the *Philos. Trans. Nrs* 268 and 270, I shall not need to give any description of them, but refer to his own much better account.

The last Instrument is what I have made use of for several years (and was it not a violation of the Rules of Modesty to speak well of my own) I would recommend it, upon my own experience, for a very nice way to find the Meridian of any place, and to see the *Transits* of the Celestial Bodies over it, either Northward or Southward.

The Instrument is thus made of Wood, or rather Iron, or Brass, to indure the Weather, without swelling or contracting, *viz.* Prepare a small flat Iron Bar, as in *Fig. 1.* C. C. At each end of which Rivet on two upright Sights, to turn stiffly, at the Joynts I. I. Let one of the Sights *c. d.* have a perforation big enough to see the Pole-Star through it; the other Sight *a. b.* a very small perforation, to see the Sun through. Just behind the Joynts fix two upright Arms C. D. & C. D, but to bend off, so as to be out of the way of the Sights, when you

look through them. These Arms ought to be long enough for the Plumb-lines to reach the Polar-Star, on one side; and the Sun at his greatest height, on the other side, when you look through either of the Sights. The Plumb-lines therefore are Tangents to their opposite Sights, and their lengths may be found by a Table of natural Tangents, and making the distance of the two Sights Radius. Thus in the Latitude of *London*, if the Instrument be two feet from Sight to Sight, the southern Plumb-line hath need to be near 4 feet, and the Northern Plumb-line about 2 feet 10 inches. On the tops of these two Arms place two small cross pieces D. E. & D. E. to turn with a Joynt at D. which Cross-pieces are to hold the Plumb-lines E. F. and E. F. and to turn off and on, so as to bring the Plumb lines to the Sights exactly. Place this Instrument on a Pedestal H to turn round on it stiffly at the Pin G.

Your Instrument being thus prepared, the way to *Set and Use it* is thus, Plant it in a convenient place, where the Polar-Star may be seen by Night, and the Sun by Day. When that Star is on the Meridian, is the time to set this Instrument, which is thus to be done; *viz.* Through the Sight with the larger Hole *c. d.* look at the Pole-Star, and turn the whole Instrument about, until you see the opposite Plumb-line nicely to intersect the Pole Star. Or when you have brought the Plumb-line near the Star, you may more easily bring the Plumb-line to intersect, by moving the Sight *c. d.* backward or forward, at the Joynt I, instead of moving the whole Instrument. And that you may more easily see the Pole-Star thro the Sight, let the Plumb-line be a very fine Cats-gut string or Horse-hair, &c. And if it be white, or some such light colour, it will be the better seen, with the help of a Candle shining on it by Night; which is necessary.

The Sight *c. d.* and opposite Plumb-line being thus set in a direct line with the Polar-Star on the Meridian, it is manifest,

manifest, that the Instrument lyeth exactly in the Meridian, so as to see any Star on the Meridian to the North. And that you may see the same Southerly; the next day, or when you please, you may hang up the Plumb-line E. F. upon the Southern arm C. D. so as that the Plumb-line may exactly intersect the Perforation *c. d.* This may easily be done by moving the top Joynt, with the Plumb-line on its Cross-piece backward and forward, till the Plumb-line hangeth to your mind. If the Sight with the lesser perforation *a. b.* be not exactly under the Northern Plumb-line, it must be brought to be so by turning the Sight, by help of its Joynt at I. And then all the Instrument is set right, so as to see the Sun, Moon or Stars come on the Meridian towards the South.

But to see the Sun transit the Meridian, it is necessary to guard the Eye, with a coloured Glass, or a Glass darkened with the smoak of a Lamp or Candle. Which, for the sake of those who do not know the way of it, it may be necessary to describe.

A Glass to look upon the Sun.

Chuse two pieces of Glass cut into the same size and figure. But take care they do not refract. Which may be known by moving the Glass before the Eye. If the objects you look on, seem to dance about, the Glasses are false and refract; but true if all seems steady. Smoak one of these Glasses over the flame of a Lamp or Candle, until it be obscured enough to take off the Sun-rays sufficiently, but not so as to darken it too much. This may be seen by looking upon the Sun with it, or upon the Candle. One of the Glasses being thus darkened, lodge them both together and fasten them in a little case fit for the purpose, with the smoaked side innermost, and an edging of Card between, to keep the Glasses asunder, so as that the Soot may not be rubb'd off, or disordered.

Tis.

'Tis good to have two Glasses thus prepared, one for a strong Sun ; the other less darkened, for the Sun behind a thin Cloud, Mist, or *&c.*

With one of these Glasses held behind, or before the Sight *a b.* you may plainly see the Sun pass.

To imitate the aforesaid Instrument in a Journey, or where-ever you come.

Instead of an intire Instrument, prepare only two Sights (as in Fig. 2.) with Perforations as before. Let these Sights be nailed or screwed down, upon the tops of two Stakes at I. I, so as to turn stiffly upon them. The Plumb-lines (one at least) may be hung up at the end of an House (as at K. Fig. 2.) or on the bough of a Tree (if the Wind would not shake it) or any where you see fit. And the Sights must be stuck up, so as to bring the Pole-Star to intersect, and all be performed, as hath been before directed.

This, although in a manner the same with the Instrument before, yet is more convenient in some respects. Chiefly because the Plumb-lines may be made longer, and the Sights set farther asunder, than in the Instrument before can conveniently be done ; which is some, altho no great advantage for seeing the Transits. Also, these Sights may be made so light, as to be easily carried about ; or they may be easily made, or imitated in any place where-ever you come.

To know when the Polar Star cometh on the Meridian.

It is necessary I should shew how this is done, for the sake of such as know it not, to whom the foregoing Instruments may be useful. The way is this, Subtract the *Right Ascension* of the Sun from the *R. Asc.* of the Pole-Star, the Remainder giveth the Degrees, Minutes and Seconds

Seconds when the Pole Star transits the Meridian above the Pole. Divide these Degrees by 15, it giveth the Hours and every Degree under 15 multiplied by 4, giveth the Minutes; and every Minute multiplied by 4, giveth the Seconds, of Apparent time of the Pole Stars Southing. I scarce need to say that it cometh under the Pole at 12 hours distance, only making some small allowance for the alteration of the Sun's R. Asc. in that 12 hours time.

But you may shorten your labour, by using Tables of the Sun's R. Asc. in *Time*, instead of his R. Asc. in *Degrees*, &c. which may be found in *Sr Jon. Moor's Math. Compend.* and in divers other Books.

If the Sun's R. Asc. exceedeth the Pole-Star's, add 360 degrees, or 24 hours, and then subtract.

The R. Asc. of the Pole-Star is determin'd by Mr *Flamsteed* to be $0^h\ 33'.\ 4''$. of *Time*, Anno 1690, and the increase of it's R. Asc. in 10 years $1'.\ 16''$. of *Time*. Therefore this present year 1703, the R. Asc. of the Pole-Star is $0^h\ 35'.\ 22''$. of *Time*.

Or you may see when the Pole-Star cometh to the Meridian, by hanging up a Plumb-line, and observing when the *Thill Horse* in *Charles's Wain*, called *Alioth*, comes near the Line, together with the Pole-Star, on one side the Pole; or the bright Star of the 3d Magnitude in *Cassiopeia's Thigh* on the other side, as is represented in Fig. 3

The for going Instruments may be set by any other Star, as well as the Pole-Star. But the Pole-Star in our Northern Hemisphere, is most convenient, because it maketh but a small circle round the Pole, and therefore moveth slower, and consequently is longer in transiting the Meridian. And therefore a small error in calculation, or a little expence of time in setting the Instrument, may be admitted, as little deserving regard.

The Uses of these Meridian Instruments.

I. You may see with all imaginable exactness, when it is *Noon* even to 1, 2, or at most 3 Seconds of Time. For you may see when the very Limb of the Sun toucheth the Meridian, and whilst all his Disk is passing it. So that by much it exceedeth all Sun-Dials: so far that if you once use this Instrument, you will be ready to lay aside all Sun-Dials; the best of which (unless we except Mr *Molineux's*) can never shew the Time to one or many Seconds.

But besides all this, another vast conveniency is, That it will fit most Latitudes. So that there is no need of having a strict regard to the Elevation of the Pole, nor any danger of error in making and setting. as is in most other Instruments, but all is with ease and certainty performed. Therefore,

2dly, Into whatsoever place you come, you may easily see the Errors of the Sun-Dials there, and which go truest, and which false.

3dly, As the Sun, so also the fixt Stars may be seen to transit the Meridian, whereby the *Hour of the Night* may as exactly be known, as of the Day by the Sun, knowing the R. Asc. of the Star that transits. For (as before for the Pole-Star) subtract the R. Asc. of the Sun from the R. Asc. of the Star, the Remainder converted into Time, is the time of that Star's Culmination or Southing. And if 12 hours be added or subtracted (making due Allowance for the alteration of the Sun's R. Asc. in that time) it sheweth the exact time of that Star's coming to the Meridian Northward.

4thly, The Hour of the Day and Night being thus to 1, 2 or 3 Seconds discoverable by the aforesaid Instruments, I doubt not but that they may be useful in finding the exact Differences of Meridians, either by the Eclipses
of

of Jupiter's Satellites, or the Occultation of the Fixt Stars by the Moon.

I do not pretend that these Instruments are any other-wise useful in finding the Longitude, than by shewing the exact time of the Day or Night; which is one thing absolutely necessary in this matter. Neither indeed will they serve without a well adjusted Pendulum-Watch, or Pocket-Watch, that will keep time exactly from one observation by the Meridian-Instrument to another. Nor indeed are they useful on Shipboard, but only on Land, where they may remain fix'd. But on Head-lands, or any where on Shoar, they may be useful to the Seaman. And indeed (until better discoveries are made) these Meridian-Instruments may be of use, where-ever long Telescopes can be used, for seeing the Appulses of the Moon to the fixt Stars, or the Eclipses of *Jupiter's* Satellites; which is only on Land. Unless (which I have thought feasible) a convenient Standing for a Man, and a Telescope might be hung pendulously in a Ship, which (especially in a calm Sea) may be as little subject to disturbance, as the Pendulums of Watches are, which will retain their motion at Sea.

5thly, You may with all exactness continue a Meridian Line for many miles, by looking thro' either Sight, and seeing what Objects are intersected by the Plumb-lines.

6thly, These Instruments are prepared with little cost, or trouble: and easily carried about, or imitable in any Place, the latter especially, which may be made pocketable, or soon gotten.